

Viking Extended Mission Support

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TDA Mission Support

This report covers the period 1 March 1977 through 30 April 1977 and includes DSN Mark III Data System (MDS) testing, status of Viking-related tracking and command support as well as the status of the Viking DSN Discrepancy Reporting System. The DSN Operations support of Viking events and Radio Science activities are also discussed. Current progress on the major new reconfiguration of the Network is presented in the context of support for the Viking Extended Mission.

I. Viking Operations

A. Status

As of 30 April 1977, all four Viking spacecrafts continued to perform their assigned tasks. Lander 2 was sent a final set of commands on 14 April for its automatic survival mission. This automatic function will continue to operate for the next six months, providing information about the Martian weather, quakes, soil analysis, and photos. The data will be relayed to Earth via Viking Orbiter 2 (VO-2) every week and a half. The temperature at the Lander 2 location has reached the frost point of carbon dioxide but no frost has been seen in Lander 2's photos. Lander 1 remains actively controlled from the Earth with data being received by both direct and relay links.

Both Viking Orbiters continue photography and temperature and water vapor mapping of Mars, most of which is now cloudy and dusty. Every two weeks VO-1 comes within photo

range of Phobos. A close encounter with Phobos will occur during the last part of May.

B. Maneuvers

Two Mars Orbit Trim (MOT) maneuvers were performed on each of the Viking Orbiters during this reporting period. VO-2 MOT-9 occurred on 2 March 1977, with a burn time of just under 10 seconds. DSS 14 was prime for this maneuver. However, much of the maneuver was performed in the blind. The station lost lock when the switch from high-gain antenna to low-gain antenna took place, and because of the proximity to periapsis and high doppler rates, the station could not reacquire until shortly before Earth occultation. Lock was achieved with enough time to establish that readings were nominal and that a "no-go" command was not required.

VO-1 MOT-13 took place on 11 March 1977, with a motor burn lasting 49 seconds. Both DSS 63 and DSS 14 supported the preburn positioning of the spacecraft for the maneuver.

DSS 14 sent the "go" command and completed the motor burn and spacecraft unwind activities. MOT-13 was nominal.

VO-1 MOT-14 occurred on 24 March 1977 with a motor burn duration of 9 seconds, resulting in a change of orbit period to 23.5 hours. The entire maneuver was conducted in the blind. DSS 42 supported the maneuver, and since the spacecraft was operating on the low-gain antenna, telemetry data was below the threshold of this station. Playback of the maneuver data took place following the return to the high-gain antenna and during the DSS 63 view period. All MOT parameters were nominal.

The final MOT of this reporting period took place on 18 April 1977 during the DSS 43 view period. VO-2 MOT-10 was accomplished on the spacecraft high-gain antenna at burn attitude. DSS 43 used receiver number 4 configured for X-band to measure the difference in downlink signal levels between VO-1 and VO-2. Link performance was normal throughout the maneuver. Later analysis by the Viking Flight Path Analysis Group determined that MOT-10 was a 5 sigma maneuver and resulted in an orbit period error of 32 seconds.

C. Radio Science

Viking Radio Science activities continued at a brisk pace during this reporting period. Six different types of activities were supported.

1. Occultation. VO-2 occultations continued during the entire reporting period. VO-1 occultations resumed on 22 March 1977 and continued during the remainder of the period. It was noted by the Radio Science Team that Earth occultation coverage was very sparse. The causes of this poor coverage were conflicts in DSS coverage, orbiter maneuvers, lander direct links, Voyager ranging passes, etc.

2. Long/short baseline ranging for Voyager. This experiment was conducted for the Voyager Project using the Viking Orbiter spacecrafts on seven occasions during March and April. The experiment called for near simultaneous ranging at S- and X-band frequencies using up to three separate DSN stations.

3. Solar Wind Experiment. This experiment took place on 7 April 1977 during a DSS 43/14 overlap. The experiment compared the S- and X-band doppler perturbations caused by solar winds on the downlink signals from VO-2. It was similar to the experiment conducted during May 1976 and used four doppler streams, two S- and two X-band, at a sample rate of one per second for the entire 4.5-hour overlap.

4. Viking/Quasar VLBI Experiment. The VLBI experiment was completed four times during March and April. The basic

purpose of this experiment is to determine the position of Mars relative to the quasar reference frame.

5. Lander and Orbiter near-simultaneous ranging. This test is used primarily to calibrate for ranging group delay due to interplanetary and ionospheric plasma. The Orbiter S- and X-band ranging can be used to measure the total electron content in the beam between the spacecraft and the station, and these calibrations are extrapolated back to the Lander ranging measurement time to get a more accurate Lander measurement. This experiment was conducted five times during March.

6. Voyager dedicated demonstration day. This experiment used DSS's 14 and 43 on 13 and 14 April 1977 to determine the effect of the 64-meter antenna subreflector movement on range measurements. It also involved near-simultaneous ranging between DSS 11, 14, 42, and 43.

D. Orbiter Visual Imaging Science

The first 16 kbps from either Viking Orbiter since Mars Orbit Insertion of VO-1 took place on March 26 and 28. The telemetry SNR averaged between 1.8 and 1.0 dB, with the lowest SNR influenced by icing conditions on the DSS antenna. On 28 March, both Orbiters played back 16 kbps, with VO-1 SNR about 2 dB with the spacecraft ranging channel on and VO-2 SNR about 3 dB with the ranging channel off. The bit error tolerance on VO-1 was set to five bits in order to permit ground processing of the data.

II. Network Support

Table 1 continues the listing of DSN tracking support for Viking reported in the last article of this series. It can be seen that the total number of passes and hours tracked has decreased from the last report. This is due in part to the fact that DSS 14 was taken out of operation on 16 April for the MDS reconfiguration. DSS 12 has taken up some of this slack by supporting 24 Viking passes during April. During the first three months of this calendar year DSS 12 had supported only five passes.

Table 2 lists the total number of commands transmitted for Viking during 1977. Table 3 shows the Discrepancy Report (DR) status for 1977. The total number of new DR's has decreased during this reporting period while the total of closed DR's has increased significantly.

The DSN Post-Track Report was eliminated on 1 March 1977. This report summarized pertinent data and events which occurred during a DSS tracking period. The report was transmitted to JPL and the Viking Project at the conclusion of each tracking period and was used by cognizant personnel at JPL as

the official source for data used to generate quick-look reports, post-track performance, data analysis and data validation functions. The requirement was to transmit this report within three hours of the end of track. Since teletype reporting and data transmission has decreased in the past few years, many of the DSS's do not have qualified teletype operators on duty throughout the week. This made it difficult for them to comply with the three-hour reporting requirement.

A new system is presently in use in which the information formally reported in the Post-Track Report is now reported by voice by the DSS to the Network Operations Controller at the conclusion of each pass. This information is logged and then made available for Project use.

III. Mark III Data Subsystem Testing

As indicated in the last report, DSS 12 had completed its Viking MDS test schedule and had been placed under configuration control. DSS 62 had completed the OVT portion of the schedule and was about to begin the remainder of the program. DSS 44 had not completed the MDS implementation and had not yet begun the test program.

During this reporting period, both DSS 62 and DSS 44 completed the Viking tests and are now under configuration control. A brief description of the tests conducted during March and April and the results are as follows:

A. DSS 62

1. Demonstration pass — 6 March 1977. This pass was a complete success. No problems were encountered. Key items accomplished during the pass were processing of VO-1 engineering data, transmission of a test command, processing of monitor data, and radio metric data.

2. Demonstration pass — 17 March 1977. Although many minor operational problems occurred during this pass, all items of the sequence of events were successfully completed. DSS 62 was placed under configuration control following this pass.

3. System Interface Test — 20 March 1977. This test was successful with all test objectives completed. A problem in the interface between the simulation center and the simulation conversion assembly at DSS 62 caused a delay of approximately five hours in the telemetry portion of the test. Following the location of a faulty communications buffer and its replacement, sufficient time remained to complete the telemetry test. This was the final DSS 62 Viking MDS test.

B. DSS 44

1. Operational Verification Test — 6 March 1977. This was the first DSS 44 OVT and considered a success. Two anomalies

occurred but did not affect the final outcome of the test. Engineering data was not received at JPL throughout the test, and monitor data would halt approximately every five minutes. This latter problem was created when both Telemetry Processor Assemblies were interfaced simultaneously with the Digital Instrumentation Subsystem Computer.

2. Operational Verification Test — 10 March 1977. This test was a complete success. All items of the SOE were completed. This was the final OVT for DSS 44.

3. System Interface Test — 18 March 1977. The test was classified as a success. All items of the sequence were completed. An interface problem between the high-speed data line and the input to the DSS simulation conversion assembly, which caused block errors, persisted throughout the test. In spite of this problem the acceptance criteria of five minutes of good data for each data rate and mode was met. No retest was required.

4. Demonstration pass — 24 March 1977. This first demonstration pass for DSS 44 was successful with all items completed. The same test criteria used previously at DSS's 12 and 62 were repeated for this test.

5. Demonstration pass — 30 March 1977. The second demonstration pass for DSS 44 was again successful. The MDA was declared red prior to this pass but did not compromise the test.

6. Demonstration pass — 20 April 1977. With one minor exception, this final demonstration pass was successful. A command bit verification failure occurred when the command system went from Idle 1 to Idle 2. Following reinitialization of the Command Processor Assembly, the problem did not reoccur. DSS 44 was placed under configuration control.

C. DSS 14

DSS 14 began its MDS reconfiguration on 16 April 1977. The Viking test program is scheduled to begin in the middle of June and will be reported on in the next article of this series.

IV. Implementation

Following the completion of the Viking Prime Mission on 15 November 1976 and the period of solar conjunction which continued through mid-January 1977, the Deep Space Network embarked on a major reconfiguration effort. This was called the Mark III-DSN Data Subsystem (MDS) implementation task and involved all stations of the Network during CY'77. It was carefully phased with the principal Flight Project Support activity, and the launch of the new Voyager Mission, as shown in the schedule in Fig. 1.

As the Viking Extended Mission increased in tempo following the solar conjunction period, important relativity experiments were conducted with DSS 14, 42 and 63 (Ref. 1, 2) while the MDS implementation activity got under way with DSS 12, 44 and 62. As each of these stations was withdrawn in turn from Viking Extended Mission Support, the MDS reconfiguration was accomplished, and the station was returned to operational support following an appropriate period of testing and crew retraining.

Some delays were experienced on the first station (DSS 12), due to unforeseen technical problems, but the time was made up on the other 26-meter stations, which were completed on schedule. By early April, these stations had been placed under configuration control and were supporting flight operations, and DSS 14, the first 64-meter station, was taken down for its reconfiguration.

It was planned to take advantage of the DSS 14 downtime for the MDS reconfiguration to carry out a number of rather long, overdue modifications and upgrades in the following areas:

- (1) Relocation of microwave tricone equipment, and modifications to the XRO feed cone.
- (2) Rehabilitation and upgrade of the main electrical power system.
- (3) Modification and improvements to the hydrostatic pump equipment.
- (4) Improvements to the water cooling and treatment plant.
- (5) Transmitter crowbar modifications and maser bypass.

Together with the MDS related tasks, this represented a substantial effort, and a special manager was assigned for the Project to coordinate and manage the resources necessary to accomplish this job on schedule. Some 87 individual modification kits were provided to the station and installed during the months of April and May.

The test schedule which followed the implementation phase is shown in Fig. 2. This allowed completion of the reconfiguration by 15 June, at which point the Viking Extended Mission Ground Data System Schedule became effective, as shown in Fig. 3.

Following a Test Readiness Review on 6 June, the tests shown in Fig. 3, were commenced, culminating in demonstra-

tion passes and the return of DSS 14 to operational status on 8 August.

V. Reconfiguration and Capabilities

The MDS modification consists of the installation of mini-computer and ancillary assemblies which replace and/or augment existing station equipments. Each minicomputer assembly consists of a Modcomp minicomputer and associated peripheral and interfacing equipment. The primary mini-computer assemblies to be installed at each station are as follows:

- (1) Telemetry Processor Assembly – replaces and expands telemetry functions of existing Telemetry and Command Processor and Data Demodulator Assembly.
- (2) Command Processor Assembly – replaces command functions of existing Telemetry and Command Processor.
- (3) Communications Monitor and Formatter – functions as part of Ground Communications Facility to provide for high-speed data communications between the Mission Control and Computing Center and MDS minicomputer assemblies. Also provides centralized data reporting and data formatting.
- (4) Metric Data Assembly – a new assembly which assumes and expands the tracking data acquisition and processing functions previously performed by the Tracking Data Handling Subsystem and the Digital Instrumentation Subsystem.

The ancillary assemblies provide functions and services necessitated by the installation of the minicomputer assemblies. The ancillary assemblies and their basic functions are as follows:

- (1) DIS MK III Interface Assembly – functions to provide a communications interface between minicomputer assemblies, providing data switching and routing functions via Star Switch Controller units.
- (2) Time Format Assembly – provides basic timing inputs (GMT and interrupts) to the minicomputer assemblies.
- (3) Data Systems Terminal – functions to provide centralized operator control and display for the minicomputer assemblies within a DSS.

The essential elements of the new MDS configuration as it will be used to support the Viking Extended Mission is shown in Fig. 4, for 64-meter and 26-meter conjoint stations.

VI. Network Configurations for Viking Extended Mission

The capabilities provided to the Viking Extended Mission by this configuration were the same as that provided for the Prime Mission, with exceptions as follows:

A. 26-Meter Stations

1. Telemetry Subsystem. Simultaneously processes two subcarriers at 8-1/3 bps uncoded and up to 2000 bps block-coded.

Changes: Telemetry Processing Assembly now replaces Telemetry and Command Processor and handles one low rate uncoded and one medium-rate block-coded stream per Telemetry Processing Assembly. Internal bit sync previously provided internal up to the Telemetry and Command Processor; this is now provided externally by the Symbol Synchronizing Assembly, one for each stream, coded or uncoded. The Digital Original Data Record is now provided by the Communications Monitor and Formatter Assembly, with the temporary Original Data Record being written by the Telemetry Processing Assembly for the recovery of data to the Digital Original Data Record.

2. Command Subsystem. Single channel PSK, 8 symbols/sec, Manchester-coded for Orbiter, with provision for manual entry.

Changes: Command subsystem incorporates additional functions of symbol-by-symbol command confirmation and Viking bit inversion to conform to industry standard. Provision for use of prepunched Mylar tapes is deleted.

3. Monitor and Control Subsystem. Local display and transmission to NOCC of station configuration, status and performance data. Existing monitor formats will continue to be available to cover the unmodified stations, with interfaces to Network Operations Control Center and Viking Mission Control and Computing Center remaining unchanged.

Changes: Special Viking high-speed data blocks for Viking Mission Control and Computing Center will be provided, and all 26-meter Deep Space Stations will be provided with Station Monitor Consoles, prior to the MDS reconfiguration.

4. Tracking Subsystem. Single channel, S-band doppler at all 26-meter stations with S-band ranging using planetary ranging assembly at DSS 12. Ranging is shared at Stations 42, 43 and 61, 63.

Changes: Metric Data Assembly now replaces Tracking Data Handling Subsystem with a temporary Original Data Record storing radio metric data at the highest sample rate, 10 samples/sec for subsequent retrieval. All text predicts are now transmitted to the Digital Instrumentation Subsystem for printing on line printer assembly. All predicts are transmitted to the Metric Data Assembly for transfer via the star switch controller to the Digital Instrumentation Subsystem for punching the Antenna Pointing Subsystem drive tape.

5. Test and Training Subsystem. High-speed simulation data from the Network Operations Control Center or Viking Mission Control and Computing Center will be received at the station by the Communications Monitor and Formatter Assembly, and routed directly to the Simulation Conversion Assembly, without passing through the star switch controller. The addition of convolution coding hardware and a MJS software module does not change existing Viking capability.

6. Voice and High Speed Data Subsystems. Provides one 7200-bps high speed line, and one voice line per station.

B. 64-Meter Stations

1. Telemetry Subsystem. Simultaneously processes two low-rate (33-1/3 bps) uncoded and two high-rate (16 kbps) block-coded subcarriers.

Changes: Total number of simultaneous data streams is reduced from six to four as described above. Telemetry Processing Assembly now replaces Telemetry and Command Processor Assembly, and each Telemetry Processing Assembly will handle one low-rate and one high-rate data channel in association with a Block Decoder Assembly for decoding the coded channel. Internal bit sync previously provided by the Telemetry and Command Processor Assembly has been replaced by the Symbol Synchronizer Assembly, one for each data stream. The low- and medium-rate Digital Original Data Record resides in the Communications Monitor and Formatter Assembly with a temporary Original Data Record being written by the Telemetry Processing Assembly for recovery of data to the Digital Original Data Record.

The high-rate Digital Original Data Record is written and recalled by the Telemetry Processing Assembly as a separate function.

2. Command Subsystem. Dual-channel PSK (8 symbols/sec) Manchester-coded for Orbiters to either Block III or Block IV exciters with provision for automatic or manual entry. The punched Mylar tape command capability is deleted.

Changes: DSS Command Subsystem incorporates additional functions of symbol-by-symbol command confirmation and Viking bit inversion to conform to industry standards. Functions formerly accomplished by the Telemetry and Command Processor Assembly are now carried on by the Command Processor Assembly, with a temporary Original Data Record providing data retrieval for the Digital Original Data Record running in the Communications Monitor and Formatter Assembly.

3. Tracking Subsystem. Two S-band doppler channels or one S-band and one X-band channel are provided. Simultaneously, two S-band or one S-band and one X-band ranging channel using the planetary ranging assembly are available.

Changes: Metric data assembly now replaces Tracking Data Handling Subsystem, with a temporary Original Data Record storing radio metric data at the highest sample, 10 samples/sec for subsequent retrieval. All text predicts are now transmitted to the DSS Monitor and Control Subsystem line printer assembly.

All binary predicts are transmitted to the Metric Data Assembly for transfer via the star switch controller to the Digital Instrumentation Subsystem for punching the Antenna Pointing Subsystem drive tape. A Meteorological Monitor Assembly, contained in the Technical Facility Subsystem, will transmit ground weather and ionospheric data via high-speed data circuits to the Network Operations Control Center.

4. Monitor and Control Subsystem. Local display and transmission to Network Operations Control Center of Deep Space Station configuration status and performance data. Existing monitor formats will continue to be available to cover the unmodified stations, with interfaces to Network Operations Control Center and Viking Mission Control and Computing Center remaining unchanged.

Changes: Special Viking high-speed blocks for Viking Mission Control and Computing Center will be provided and all 64-meter stations will continue to use SMC IIA, Station Monitor Consoles.

5. Ground Communications Facility Voice and High-Speed Data Subsystems. Provides one 7200-bps high-speed data line, one voice line per station, and one 56 kbps wideband data line per 64-m station.

6. Test and Training Subsystem. High-speed simulation data from Network Operations Control Center or Viking Mission Control and Computing Center will be received at the stations and routed directly to the Simulation Conversion Assembly via a communications buffer without passing through the star switch controller. The addition of convolution coding hardware and a Voyager software module does not change existing Viking capability. Wideband simulation data is routed directly to the Simulation Conversion Assembly as in the Prime Mission configuration.

C. Conjoint Stations

The functional design for DSS 42 and 61 conjoint stations following the reconfiguration provides all the characteristics described above for DSS 11, 12, 44, and 62 with the following exceptions:

- (1) A second Symbol Synchronizer Assembly permits simultaneous processing of one low-rate and one medium-rate Viking data stream to the Telemetry Processing Assembly, thereby retaining the simultaneous four-stream capability in the conjoint 64-meter wing.
- (2) Timing and test and training services are shared with the conjoint 64-meter stations.
- (3) Ranging is shared with the conjoint 64-meter stations.
- (4) Star switch controller and Communications Monitor and Formatter, shared with the conjoint 64-meter stations, provide combined capability for two high-speed data channels to the Complex.

VII. Future Plans

The DSN plans to continue the MDS reconfiguration around the Network as shown in the schedules in Fig. 1 and 3, with DSS 42/43 and DSS 61/63, following in order after DSS 14. The Viking Extended Mission Operations have been integrated with the Ground Data System schedule of Fig. 3, in such a way as to minimize the impact to the Mission data return as a result of the reconfiguration described above. Subsequent reports will describe the implementation and test activity as this work proceeds.

Acknowledgment

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References

1. Johnston, D. W., "Viking Mission Support," in *The Deep Space Network Progress Report 42-38*, pp. 38-42, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1977.
2. Johnston, D. W., "Viking Mission Support," in *The Deep Space Network Progress Report 42-39*, pp. 4-8, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1977.

Table 1. VEM tracking support 1977

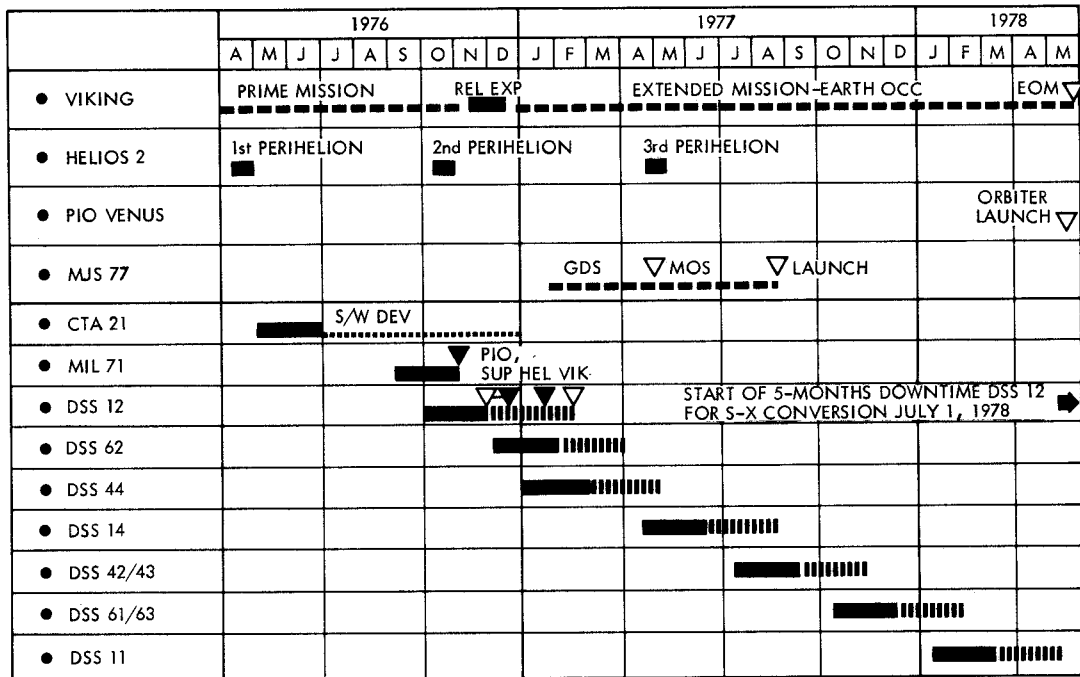
DSS	Jan		Feb		Mar		Apr	
	Tracks	Hours	Tracks	Hours	Tracks	Hours	Tracks	Hours
11	23	135	22	142	10	100:12	17	118:00
12	4	11	1	6	—	—	24	175:59
14	52	341	59	392	50	368:35	20	176:21
42	21	247	25	226	58	453:24	17	138:36
43	68	721	62	627	—	—	63	603:21
44	-0-		-0-		7	7:02	1	3:56
61	35	261	29	227	12	72:07	40	317:45
62	-0-		2	7	4	22:25	9	55:10
63	38	327	28	202	66	525:53	15	78:01
Total	241	2043	228	1830	207	1549:38	206	1667:09

Table 3. DSN VEM discrepancy reports

DSS	Jan		Feb		Mar		Apr	
	Open	Closed	Open	Closed	Open	Closed	Open	Closed
11	4		3	4	4	6	1	3
12	4						5	2
14	14	2	11	19	4	33	3	9
42		1	2	3		7		2
43	10	13	11	10		12	9	11
44						2		1
61	1	9	1	6		3		1
62				8	1	2	2	1
63	1	4	7	3	1	18		6
Others ^a	4	3	3	9	2	10	4	7
Total	38	32	38	62	12	93	24	43

^aDSN, NDPA, NOCA**Table 2. VEM commands transmitted**

DSS	Jan	Feb	Mar	Apr
11	1521	1394	1027	117
12	-0-	-0-	-0-	1314
14	769	1404	1206	274
42	2072	953	1778	8
43	919	2523	-0-	2094
44	-0-	-0-	2	1
61	605	1116	1328	1925
62	-0-	-0-	1	1991
63	795	472	2039	381
Total	6681	7862	7381	6180



■ TWO-MONTHS DOWNTIME FOLLOWED BY
 ■ TWO-MONTHS TEST AND TRAINING AND FLIGHT SUPPORT

Fig. 1. Mark III-DSN Data Subsystems Implementation Schedule

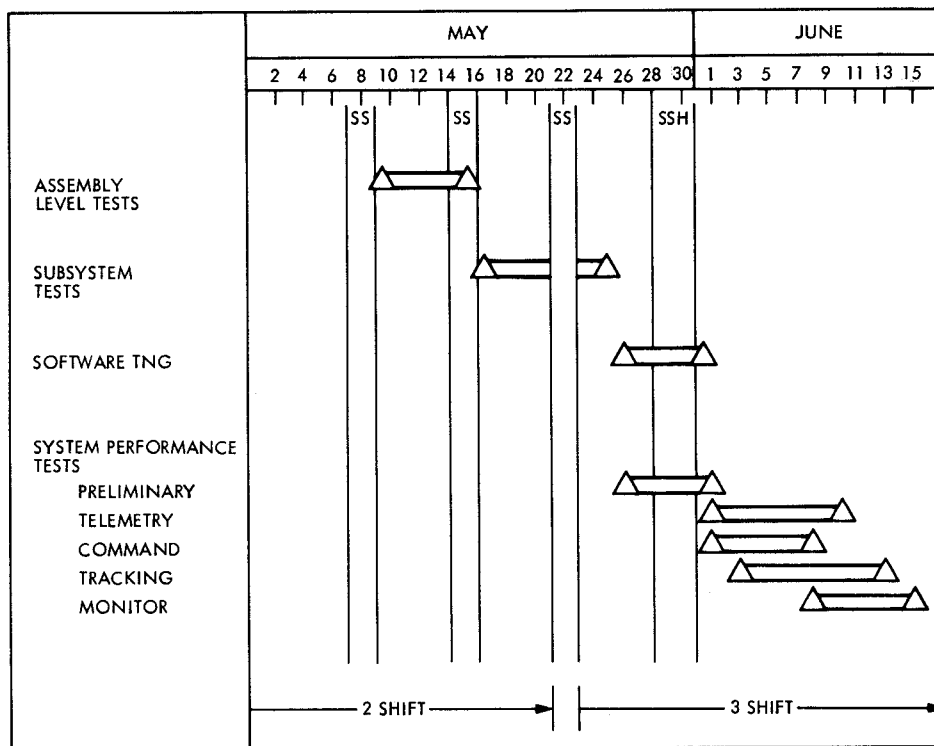
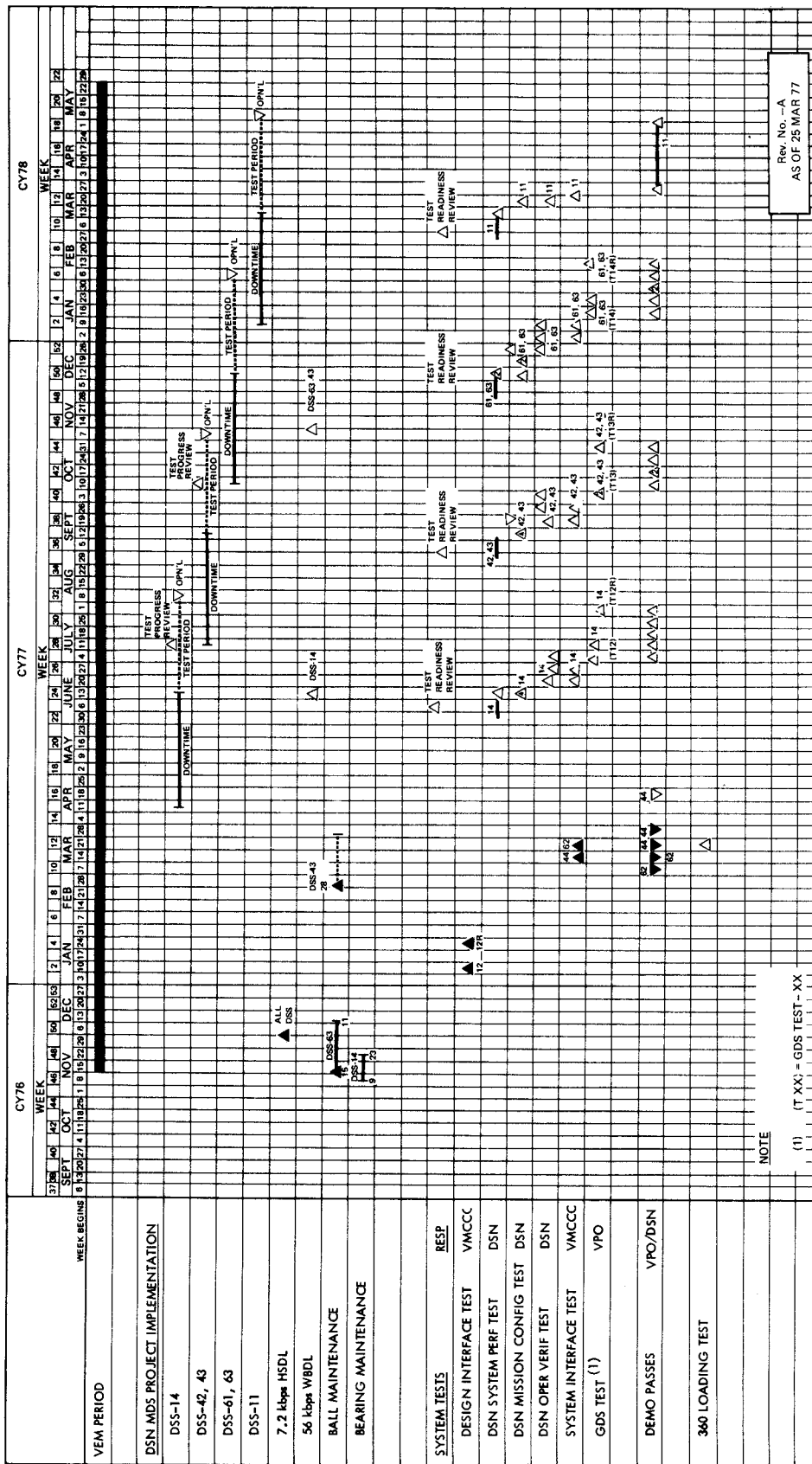


Fig. 2. DSS 14 Downtime Project, Test Schedule



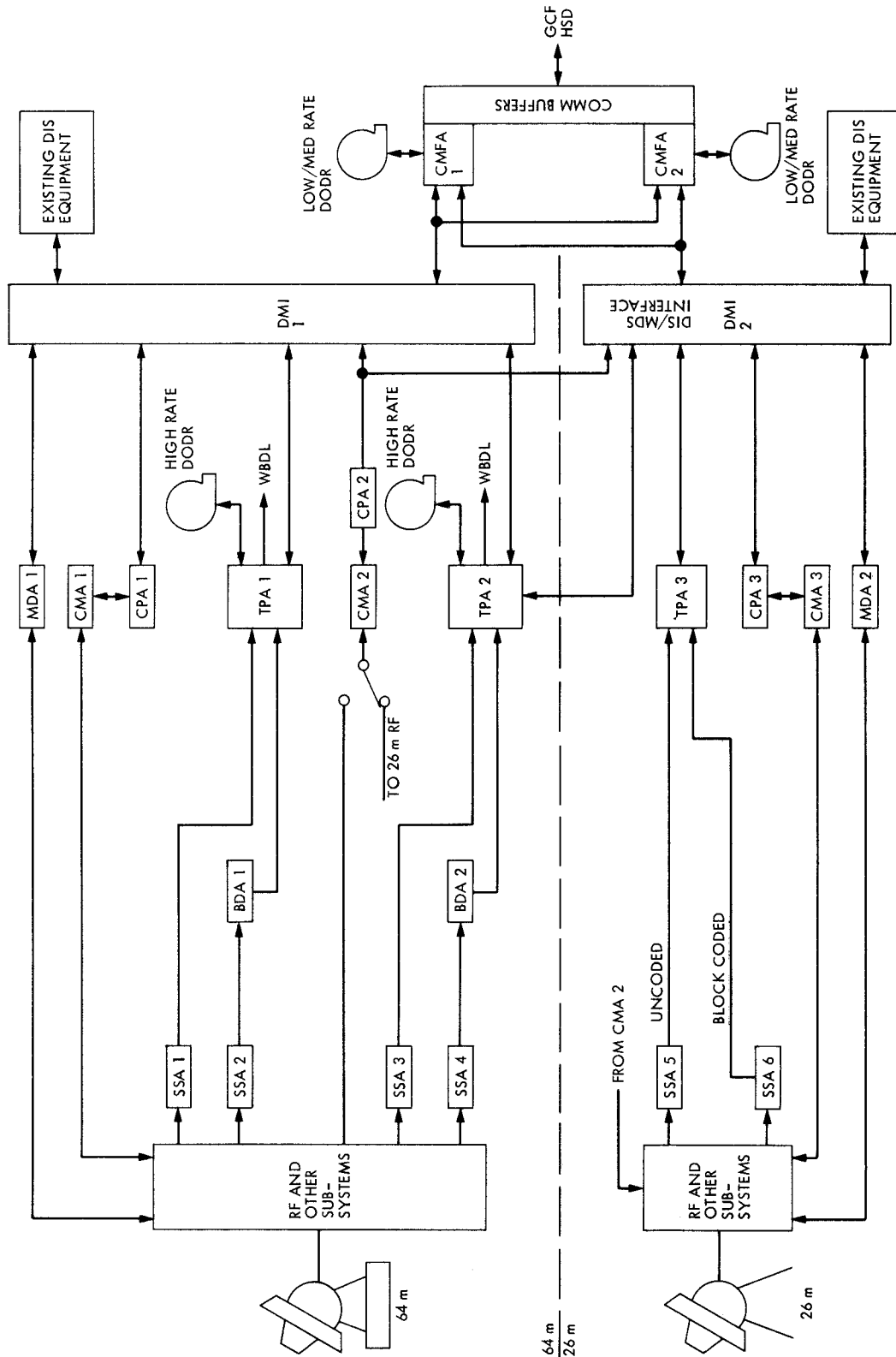


Fig. 4. Mark III-DSN Data Subsystems Implementation, New Configuration, Conjoint Stations